

Distinguishing Natural and Anthropogenic Sources of Arsenic: Implications for Site Characterization

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Both anthropogenic and natural sources contribute to the presence of arsenic in soil and groundwater. Understanding both source types, as well as the geochemical conditions for a given site should be considered important in developing and implementing an effective site characterization program, and ultimately, a technically feasible and cost-effective management or remediation program. Anthropogenic sources of arsenic, including mineral processing, glass manufacturing, wood preserving, pesticide production and application, landfill/waste pile leaching, and coal/oil production and processing, typically are localized and seldom result in regional increases in arsenic concentration with the possible exception of the wide-spread application of arsenical-pesticides/herbicides. Natural sources of arsenic, of which there are nearly 250 naturally-occurring arsenic-containing minerals, including volcanically-derived sediment, sulfide minerals, and metal oxides, can affect large areas. The “background” contribution of the natural sources creates additional complexity in assessing the impact of arsenic at a given site with respect to developing appropriate site solutions.

Arsenic is a redox-sensitive element, and its presence, distribution, and mobility is dependent on the interplay of several geochemical factors including reduction-oxidation reactions, pH conditions, microbial activity, the distribution of other ionic species, and general solution chemistry of pore-water or groundwater. These factors, which are influenced by both natural and human-based conditions and activities, in turn control the major adsorption/desorption and precipitation/dissolution reactions that influence arsenic mobility. The two primary redox forms of arsenic, arsenate and arsenite, can occur in almost any hydrogeochemical setting, although arsenate generally predominates under oxidizing conditions with arsenite predominating under reducing conditions. For waste site settings (e.g., anthropogenic sources), the type of arsenic present in the subsurface will be strongly affected by the contributions of other waste types, including hydrocarbon compounds, which tend to affect pH and redox conditions of the subsurface system, as well as the form that the arsenic was released as. Crude arsenic trioxides typically contribute to the presence of arsenates in near-surface, oxygenated soil and groundwater. Reduction due to the presence of hydrocarbon contributions can, in turn, result in the reduction and change of mobility of the arsenic ion. Local releases of sulfuric or nitric acids in waste streams, can in turn, reoxidize arsenite to arsenate. Because conditions can change greatly over short distances in such release sites, site characterization programs must involve a comprehensive understanding of the history of releases, as well as background information with respect to ambient site conditions.

This presentation will discuss issues associated with the types and conditions of arsenic sources and release scenarios, as well, as the characterization techniques important to developing a representative interpretation of the site conditions.